DOI:10.5937/IIZS25393D

HYGIENIC CORRECTNESS OF DRINKING WATER OF ZRENJANIN

Milana Drašković[1], Danijele Jašin[1], Gelert Gligor[2]
[1]Technical College of Applied Studies, Zrenjanin, Serbia
[2] Public Utility Company Waterworks and Sewerage, Subotica,Serbia
e-mail: draskovic.milana@gmail.com.

Abstract: Drinking water must be safe for the health of the people who consume it. The quality of drinking water consists of physico-chemical and microbiological parameters. In order to preserve the microbiological integrity of drinking water, it is necessary to continuously monitor the source and the distribution network, as well as maintain them. Disinfection of raw water by chlorination is also necessary. The aim of this work is to examine the physico-chemical and microbiological parameters of drinking water and indicate risk analysis, control measures that can affect the prevention and elimination of pollution in order to maintain the microbiological integrity of drinking water in the city of Zrenjanin.
Key words: drinking water, physico-chemical parameters, microbiological control

INTRODUCTION

Drinking water that is used for public supply to the population or for the production of foodstuffs intended for sale is subject to testing for hygienic correctness carried out by authorized health institutions [1,2].
The origin of the drinking water of the Middle Banat district is from the second and third aquifers, from depths of about 60-130m. Water is disinfected with chlorine preparations and distributed to consumers without any purification process [3,4,5]. The dominant way of water supply is central. For each drinking water quality parameter, there are standards for maximum allowable concentrations. The results of all physical, chemical and microbiological parameters of drinking water should be within the permitted limits and to meet the applicable regulations for quality and health safety drinking water.
The town of Zrenjanin is supplied with water from a source located on the road to Mihajlovo. In the current mode of operation of the "Mihajlovačka" spring, 220 l/s is exploited on average (on an annual basis). Of the measures to correct the quality of underground water, only disinfection is carried out.
At the "Mihajlovačka" source, 57 wells were built, in two lines at a distance of about 1250 meters, of which 32 are in active operation. The wells capture water from outcrops that capture aquifers from a depth of 35 to 80 m and from 90 to 140 m. Disinfection of water is carried out in the JKP "Vodovod i Kanalizacija" Zrenjanin by chlorination as preparation of water for drinking and distribution in the city of Zrenjanin.
The preparation process takes place continuously. Two lines of springs are in use, with 15 wells each in use. Pipelines start from each location of the well and extend to the very location where chlorination is performed. The main pipelines are in the direction Mihajlovo-Zrenjanin and supply the city with water [6].
The purpose of adding a secondary disinfectant is to maintain the quality of drinking water in the distribution system to the final consumer, that is, to maintain the achieved level of water quality.
The most important pipelines in the existing distribution network of the city of Zrenjanin that transport the necessary amounts of water to the main connections of the distribution network and carry out the final supply and distribution of water to consumers are:
• Western transit pipeline,
• The main supply pipeline to the center and southeastern parts of the city,
• Eastern transit pipeline.
In this paper were analyzed physico-chemical and microbiological parameters samples of drinking water town Zrenjanin. From the analysis of drinking water town Zrenjanin, it is

determined, at any time, if there is deviation from the maximum allowable concentrations of the individual investigated parameters.

MATERIAL AND METHODS

Physico-chemical and microbiological analysis of drinking water samples from the central water supply in the territory of the city of Zrenjanin were conducted in the period from January to June 2021.

Control of the hygienic suitability of drinking water in the city of Zrenjanin was carried out in the accredited laboratory of the "Public Health Institute" in Zrenjanin, in accordance with the criteria prescribed by the Rulebook on the hygienic suitability of drinking water ("Official Gazette of the SRJ", No. 42/98 and 44/99 and "Official Gazette of the RS", No. 28/2019) [7] and the Rulebook on the method of sampling and methods for laboratory analysis of drinking water (Official Gazette of the SFRJ No. 33/87) [8] and Council Directive 98/83/EC and [9].

Physical and chemical analysis of raw and chlorinated water samples were performed:

- Volumetric methods (quantitative determination of organic matter, consumption of $KMnO_4$, chloride content Cl,)
- Electrochemical method (pH value)
- Conductometric method (electrical conductivity)
- Spectrophotometric methods (content: nitrate, nitrite, ammonia, iron, manganese)

For microbiological analysis, samples were taken at 14 points in the city of Zrenjanin, and the following microbiological parameters of the basic "A" scope examination were performed:

- Total number of culturable microorganisms, test method SRPS EN ISO 6222:2010

RESULTS AND DISCUSSION

As for the quality of the underground water used for the water supply of the population and economy of the city of Zrenjanin, although it is not uniform, it can be safely said that the water is alkaline (pH 7.4-8.9), with a total alkalinity of about 650 $CaCO_3$. The color of the water is mostly yellow and is determined by the high content of organic matter of natural origin ($KMnO_4$ consumption is 14-95 mg/l), i.e. the presence of humic and fulvic acids. Increased amounts of organic matter occur due to the impossibility of their decomposition to the ultimate inorganic elements (carbon dioxide, nitrogen, nitrates) due to the lack of oxygen and bacteria in the water, so the organic matter practically remains conserved in it.

According to its inorganic content, the underground water of the source of the water supply in Zrenjanin belongs to the sodium-hydrocarbonate type. Of the cations, sodium dominates, in concentrations of 200-300 mg/l, which are above the maximum permissible concentrations in drinking water, while the concentrations of calcium (2-70 mg/l) and magnesium (7-30 mg/l) are extremely low, which is very rare in deep underground waters.

Of the anions, hydrocarbons dominate (708-970 mg/l), while the concentrations of sulfates (3-90 mg/l), chlorides (5-50 mg/l) and fluorides (0.1-1.0 mg/l) are extremely low compared to the usual values for groundwater.

The content of ammonia (0.1 - 3.2 mg/l) and iron (0.1 - 1.3 mg/l) is generally above the maximum allowed concentration for drinking water. The origin of ammonia is most likely nitrate (created by the reduction of nitrates in anaerobic conditions, as indicated by the low concentrations of nitrates in the tested water samples. Both ammonia and iron have a bad effect on organoleptic properties (ammonia has an unpleasant smell, and iron makes water bitter), but they are not dangerous for the health of consumers.

The quality and safety of the drinking water town Zrenjanin, is observed by physical-chemical and microbiological analysis.Tables 1 and 2 show the results of raw and chlorinated water monitoring, followed by comparative continuous sampling in the first half of 2021.

Table 1. *Raw water analysis results*

The parameters	Unit	Maximum allowed	Sample1 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
Temperature	°C	source temperature or lower	14,8	15,2	15,4	14,4	16,0	15,6	13,8
Chlorine residual	mg/l	0,5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Color	°Pt/Co	5	55	51	47	52	40	39	44
Turbidity	NTU	1	0,33	0,11	0,36	0,02	0,02	0,04	0,26
pH	/	6,8-8,5	7,98	8,23	8,19	8,25	8,33	8,26	8,09
Consumption of $KMnO_4$	mg/l	12	43,64	41,13	40,5	45,53	42,39	41,72	42,35
Ammonia (NH_3)	mg/l	0,5	1,93	1,73	1,46	1,42	0,95	1,01	1,48
Chlorides (Cl)	mg/l	250	12,46	12,46	14,48	12,46	5,38	<5	12,12
Nitrite (NO_2)	mg/l	0,03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate (NO_3)	mg/l	50,0	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
The rest of the fumes	mg/l	/	819	745	803	807	730	731	775
Conductivity	µS/cm	2500	1322	1234	1258	1253	1125	1155	1169
Iron (Fe)	mg/l	0,3	0,61	0,6	0,58	0,44	0,2	0,22	0,57
Orthophosphates (P)	mg/l	0,15	0,68	0,62	0,7	0,59	0,55	0,45	0,54
Arsenic (As)	mg/l	0,010	0,091	-	-	-	-	-	-
Aerobic mesophilic bacteria			0	6 AMB	4 AMB	0	2 AMB	2 AMB	0

Table 2. *Chlorinated water analysis results*

The parameters	Unit	Maximum allowed	Sample 1	Sample .2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
Temperature	°C	source temperature or lower	9,1	9,1	9,1	10,0	13,3	14,0	10,6
Chlorine residual	mg/l	0,5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Color	°Pt/Co	5	46	43	43	42	40	39	40
Turbidity	NTU	1	0,28	0,12	0,31	0	0,02	0,07	0,02
pH	/	6,8-8,5	8,16	8,27	8,240	8,19	8,16	8,27	8,07
Consumption of $KMnO_4$	mg/l	12	39 25	39,82	41,13	40,46	38,62	37,93	39,82
Ammonia (NH_3)	mg/l	0,5	1,06	0,78	0,94	0,83	0,78	0,85	0,98
Chlorides (Cl)	mg/l	250	12,79	10,77	11,11	11,78	10,77	10,77	12,12
Nitrite (NO_2)	mg/l	0,03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate (NO_3)	mg/l	50,0	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
The rest of the fumes	mg/l	/	751	749	728,000	758	759	746	769
Conductivity	µS/cm	2500	1233	1168	1193	1192	1157	1185	1182
Iron (Fe)	mg/l	0,3	0,35	0,24	0,31	0,25	0,22	0,24	0,4
Orthophosphates (P)	mg/l	0,15	0,61	0,51	0,6	0,56	0,57	0,51	0,57
Arsenic (As)	mg/l	0,010	0,126	-	-	-	-	-	-
Aerobic mesophilic bacteria			0	0	1 AMB	0	1 AMB	0	0

The diagrams show variations of parameters that exceed the maximum allowed concentrations, namely: color, consumption of $KMnO_4$, ammonia, iron, orthophosphates and arsenic in the analyzed samples of raw and chlorinated water (Fig. 1,2,3,4,5,6).
Based on the diagram, it can be concluded that there are correlations of the decrease in the content of the mentioned parameters, except in the case of arsenic, as a result of oxidation due to chlorination of raw water. The increase in arsenic can be explained by the partially destroyed organic matter from which part of the arsenic was separated, due to oxidation by chlorination.

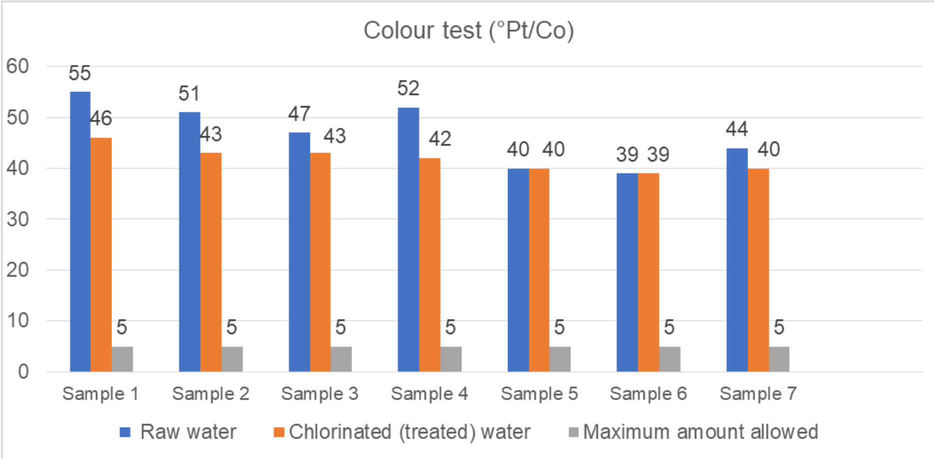

Fig. 1. *Color in the analyzed samples of raw and chlorinated water in relation to the maximum allowed value*

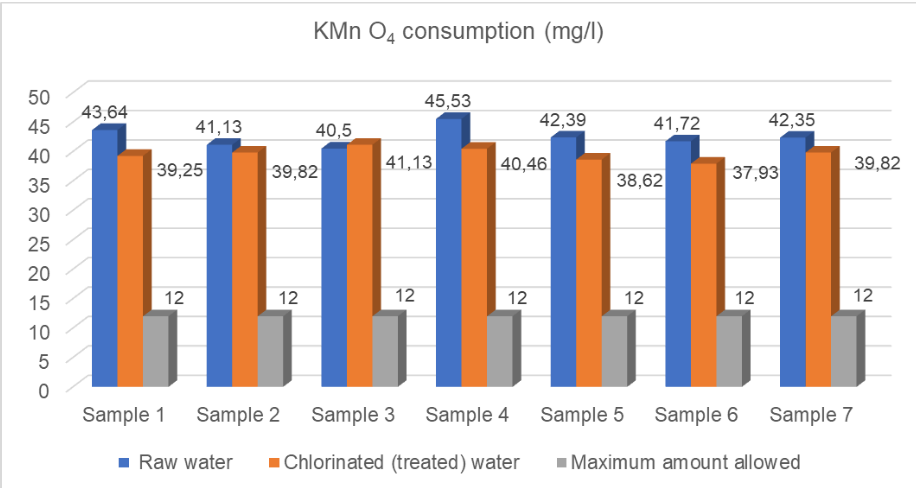

Fig. 2. *Consumption of $KMnO_4$ in the analyzed samples of raw and chlorinated water in relation to the maximum allowed concentration*

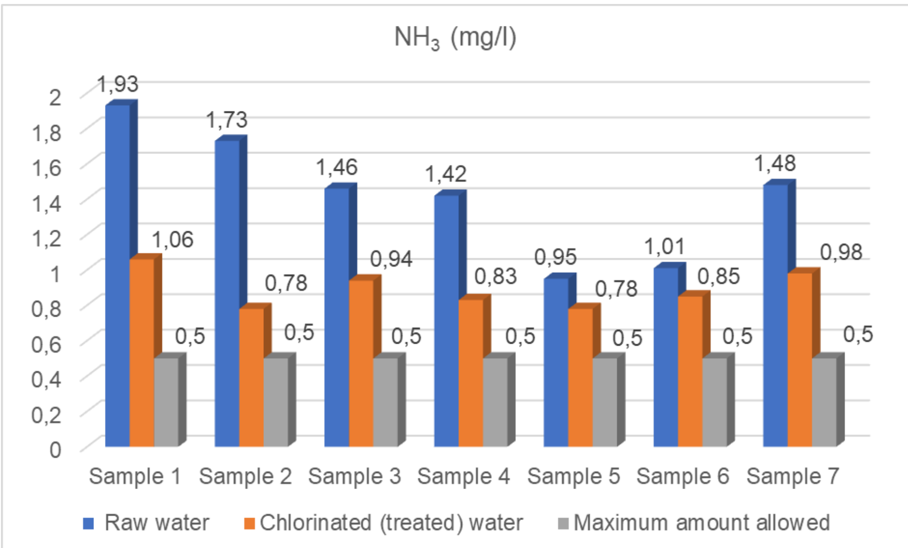

Fig. 3. *Concentration NH_3 in the analyzed samples of raw and chlorinated water in relation to the maximum allowed concentration*

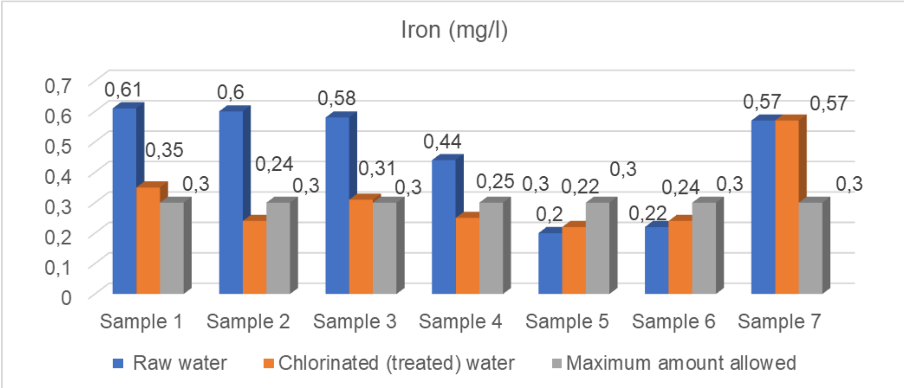

Fig. 4. *Concentration iron in the analyzed samples of raw and chlorinated water in relation to the maximum allowed concentration*

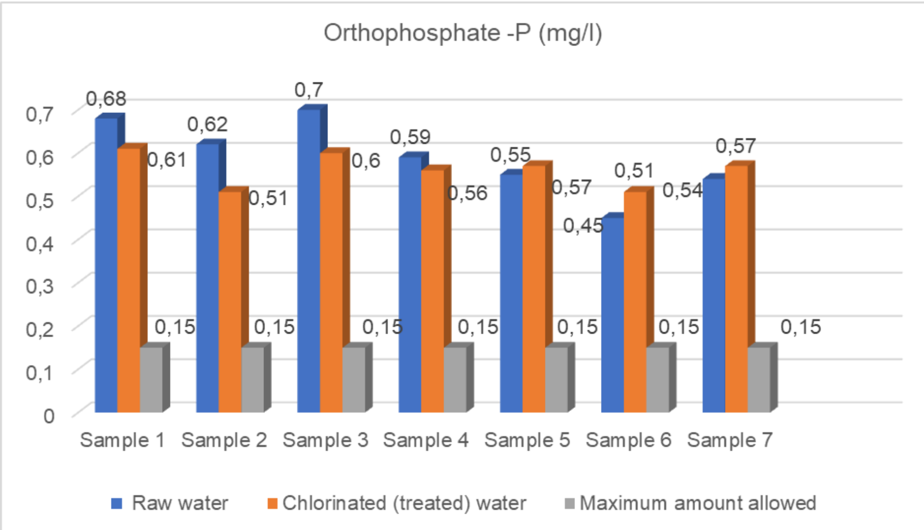

Fig. 5. *Concentration orthophosphate in the analyzed samples of raw and chlorinated water in relation to the maximum allowed concentration*

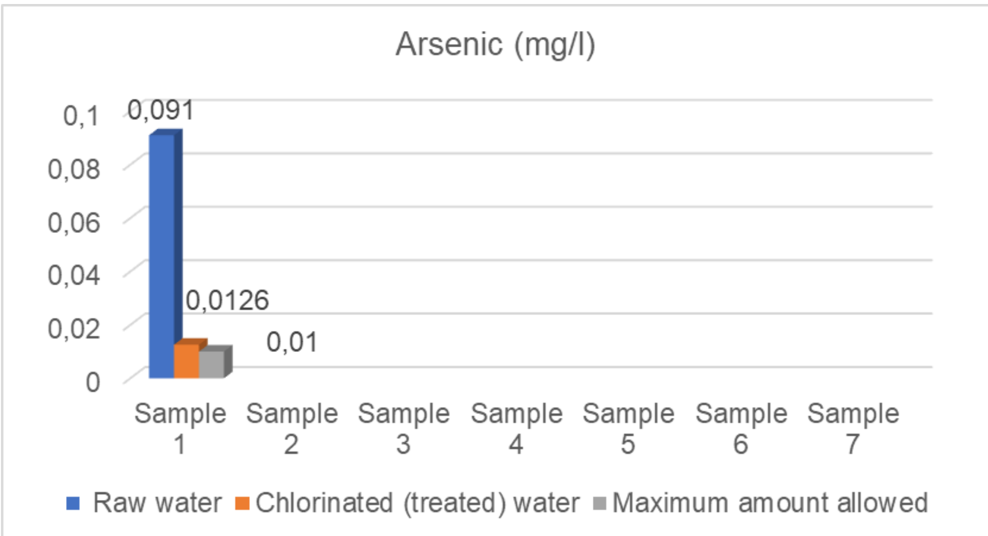

Fig. 6. *Concentration arsenic in the analyzed samples of raw and chlorinated water in relation to the maximum allowed concentration*

CONCLUSION

In the results of the hygienic correctness of the analyzed samples of raw water, one can see variations of parameters that exceed the maximum allowed concentrations, namely: color, consumption of KMnO4, ammonia, iron, orthophosphates and arsenic. The underground water used for the water supply of the city of Zrenjanin has a specific and extremely complex physical and chemical composition of the water, which has been intensively used for decades and will continue to be used as the main drinking water resource in the future.
Thanks to the long-term interaction with the sediments in which it is located, the underground water gradually washed out various mineral and organic ingredients from them, incorporated them into its structure and became increasingly burdened with the taken-over substances. The consequence of that is that the quality of the deep waters of the northern and central Banat, could never satisfy many of the criteria of the rulebook on the hygienic correctness of drinking water.

REFERENCES

[1] Dalmacija, B., Tomin, M.B., Kontrola kvaliteta vode za piće od izvorišta do potrošača, Departman za hemiju, biohemiju i zaštitu životne sredine, PMF, Novi Sad, 2015.
[2] Šćiban, M., Prodanović, J., Tehnologija vode I deo - kvalitet vode i sistem za vodosnabdevanje, Tehnološki fakultet, Novi Sad, 2021.
[3] Dalmacija, B., Agbaba, J Klašnja, M., Savremene metode u pripremi vode za piće, Departman za hemiju, biohemiju i zaštitu životne sredine, PMF, Novi Sad, 2009.
[4] Rowland, A.L.H., Omoregie, O. E., Millot, R., Jimenez, C., Mertens, J., Baciu, C., Hug J. S., Berg, M., Geochemistry and arsenic behaviour in groundwater resources of the Pannonian Basin (Hungary and Romania), 26, pp, 1-17, 2011.
[5] Barringer, L. J., Mumford, A., Young, Y .L., Reilly, A. P., Bonin L. J., Rosman, R., Pathways for arsenic from sediments to groundwater to streams: Biogeochemical processes in the Inner Coastal Plain, New Jersey, USA, Water Research, 44, (19), pp. 5532-5544, 2010.
[6] Protić, I., Drašković, M., Jašin, D., Mikrobiološka kontrola vode za piće grada Zrenjanina, Zbornik radova sa 43. Međunarodne konferencije Vodovod i kanalizacija, Zrenjanin, str. 116-21, 2022, ISBN 978-86-80067-53-7.
[7] Pravilnik o higijenskoj ispravnosti vode za piće („Sl. list SRJ", br. 42/98 i 44/99 i „Sl.glasnik RS", br. 28/2019)
[8] Pravilnik o načinu uzimanja uzoraka i metodama za laboratorijsku analizu vode za piće. (Službeni list SFRJ br. 33/87).
[9] Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption ,Official Journal L 330 , 05/12/1998 P. 0032 – 0054.